



Supplement of

Rock glacier characteristics serve as an indirect record of multiple alpine glacier advances in Taylor Valley, Antarctica

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Table S1. Major ions from ice cores from buried ice, frozen ponds, and alpine glaciers

Sample	Depth (cm)	Br (ppm)	Ca (ppm)	Cl (ppm)	F (ppm)	Fe (ppm)	K (ppm)	Mg (ppm)	Mn (ppm)	Na (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	PO ₄ (ppm)	Si (ppm)	SO ₄ (ppm)
Buried ice															
SLI-1	0		3.232	15.883	0.084	0.263	0.461	1.581	0.007	6.324		0.567		0.601	3.918
	75		3.665	30.808	0.057	0.240	0.429	2.908	0.005	7.897		1.074		0.370	4.894
	114		2.357	30.654	0.043	0.337	1.643	3.725	0.007	8.427		1.156		0.630	1.607
	143	0.055	7.285	47.558	0.099	0.670	1.471	7.140	0.015	11.066		1.994		1.020	5.903
SLI-4	15		4.151	7.673	0.064	0.501	0.624	0.609	0.009	4.187		0.229		0.750	7.271
	65		5.044	11.027	0.041	0.129	0.427	1.123		5.595		0.284		0.341	13.205
	149		8.043	21.213	0.068	1.142	1.068	3.050	0.024	6.856		0.979		1.560	17.487
SLI-5	15		0.651	9.592		0.087		0.140		5.810		0.499	0.050	0.277	1.044
	137		0.874	12.582		0.140	0.430	0.170		7.395		0.483		0.366	1.251
	210		0.907	14.379		0.105		0.219		8.109		0.459		0.259	1.514
SLI-08A	3		0.608	3.183	0.026	0.843	0.564	0.479	0.021	2.012		0.206	0.117	1.165	0.503
SLI-08B	3		0.622	1.876		0.762		0.439	0.019	1.067	0.012	0.227	0.095	0.801	0.373
SLI-08C	3		0.284	1.951		0.218		0.200	0.004	1.205	0.016	0.163	0.166	0.317	0.230
SLI-09A	3	0.051	2.145	13.737	0.062	0.149	0.390	1.321	0.006	5.475		0.407		0.331	2.181
SLI-09B	3		0.452	5.756	0.030	0.130	0.326	1.229	0.004	1.451	0.013	0.628	0.140	0.205	0.378
SLI-11	5		6.109	9.607		1.988	0.650	1.067	0.070	5.764		0.481	0.173	2.269	5.772
SLI-12	5	0.084	5.074	9.656	0.118	0.407	1.029	2.505	0.021	5.363		0.866	0.196	0.922	3.222
SLI-13	5		4.701	17.819	0.066	0.305	0.435	2.406	0.010	5.499		1.078		0.385	5.607
SLI-14	5	0.083	2.627	5.147	0.053	1.019	0.444	0.743	0.028	3.391	0.024	0.333	0.107	1.466	1.756
SLI-15	5	0.133	2.659	17.882	0.029	0.804	0.751	2.426	0.021	3.843		1.494	0.145	1.082	3.383
Ponds															
SLI-2	0		0.100	0.320	0.050	0.047		0.023		0.121		0.136		0.161	0.085
	21		0.166	0.105	0.043	0.027		0.020		0.066	0.006	0.350	0.051	0.180	0.057
	53		0.081	0.061	0.033			0.011		0.068		0.051	0.051	0.135	0.039
	74		0.105	0.375	0.050	0.013		0.021		0.109		0.154		0.166	0.117
SLI-6	0		0.431	1.569	0.037	0.019		0.153		0.687		0.285		0.201	0.973
	10		0.270	0.806	0.035	0.025		0.083		0.391		0.248	0.056	0.213	0.491
	10*		0.287	0.790	0.035			0.083		0.403		0.222		0.192	0.463
KWL-01	3		3.139	3.260	0.161	0.303	0.943	0.721	0.011	2.334	0.161	0.238	0.064	0.866	2.186
KWL-02	3		10.226	80.281	0.659	0.414	3.960	11.920	0.014	26.572		1.903	0.055	0.904	14.030
KWL-03	3	37.405	2675.000	31378.090	8.006		704.412	8826.545	1.091	10673.190		209.167		1.608	465.176
SLI-010	3		2.354	5.571	0.076	0.073	0.352	1.291		2.005		0.350	0.060	0.211	1.426
SLI-016	3	0.145	17.600	193.816	0.252	0.036	5.295	32.458	0.003	57.004		4.166		0.155	23.134
SLI-017	3		2.459	4.833	0.072	0.109	0.977	1.345	0.004	3.449		0.329	0.076	0.309	3.236
SLI-018	3	0.086	0.122	0.301	0.071	0.055		0.071		0.219		0.123	0.108	0.155	0.235
SLI-019	3	0.238	0.338	1.217	0.086	0.229		0.213	0.005	0.456	0.036	0.272	0.059	0.361	0.281
Glacier ice															
Doran	Gl.	0.069	0.422	2.090		0.459		0.592	0.015	0.762		0.348	0.145	0.516	0.480
Sollas	Gl.		1.564	1.930		1.080	0.525	0.913	0.031	1.318		0.340	0.071	1.540	8.747

Sample names are abbreviated, SLI-15-01 is listed as SLI-1 and so on. Glacier ice was sampled from the terminus, therefore meltwater activity is possible.

Where concentrations fall below detection limits or below 0.05 mg kg⁻¹, cells are left blank. Reported detection limits (in ppm) were: Br (0.05), Ca (0.027), Cl (0.02), F (0.02), Fe (0.004), K (0.134), Mg (0.042), Mn (0.002), Na (0.027), NO₂ (0.005), NO₃ (0.05), PO₄ (0.05), Si (0.047), SO₄ (0.02).

* Denotes a duplicate sample.

Table S2. Stable isotopic data from buried ice (cores and hand samples), ponds and glaciers.

Core / Sample ID ^a	Core / sample depth (cm) ^b	$\delta^{18}\text{O}$ (‰)	δD (‰)
Buried ice cores			
SLI-15-01	0	-30.8	-249.8
	1	-31.8	-256.1
	2	-32.4	-261.1
	3	-33.1	-270.0
	5	-33.2	-271.3
	6	-33.6	-271.7
	7	-33.4	-269.9
	9	-33.1	-269.2
	52	-30.2	-245.8
	65	-29.8	-242.1
	80	-30.0	-242.9
	97	-29.7	-242.3
	99	-29.9	-244.1
	108	-29.0	-238.8
	124	-28.2	-232.2
	134	-30.1	-245.8
	144	-30.4	-248.3
SLI-15-04	0	-29.4	-237.0
	2	-29.7	-239.9
	3	-30.1	-243.3
	4	-30.0	-242.6
	5	-29.8	-241.9
	11	-30.0	-244.7
	21	-28.4	-232.6
	22	-28.3	-233.3
	28	-29.4	-241.1
	29	-29.2	-240.3
	44	-28.2	-231.3
	57	-29.9	-243.4
	70	-30.2	-245.7
	113	-29.1	-239.5
	124	-29.1	-239.1
	137	-29.5	-241.9
	146	-28.9	-238.7
	155	-29.4	-240.0
SLI-15-05	16	-32.8	-266.2
	29	-33.4	-270.0
	41	-33.8	-274.6
	54	-34.2	-277.0
	66	-33.6	-274.0
	75	-33.6	-272.2
	90	-33.3	-269.7
	112	-33.3	-269.7
	124	-33.4	-271.9
	136	-33.2	-271.7
	149	-29.4	-239.4
	150	-33.6	-271.6
	193	-34.3	-279.0
	209	-31.8	-262.7
	227	-33.9	-274.9

^a See Tables 1 and 2 for sample locations and descriptions.

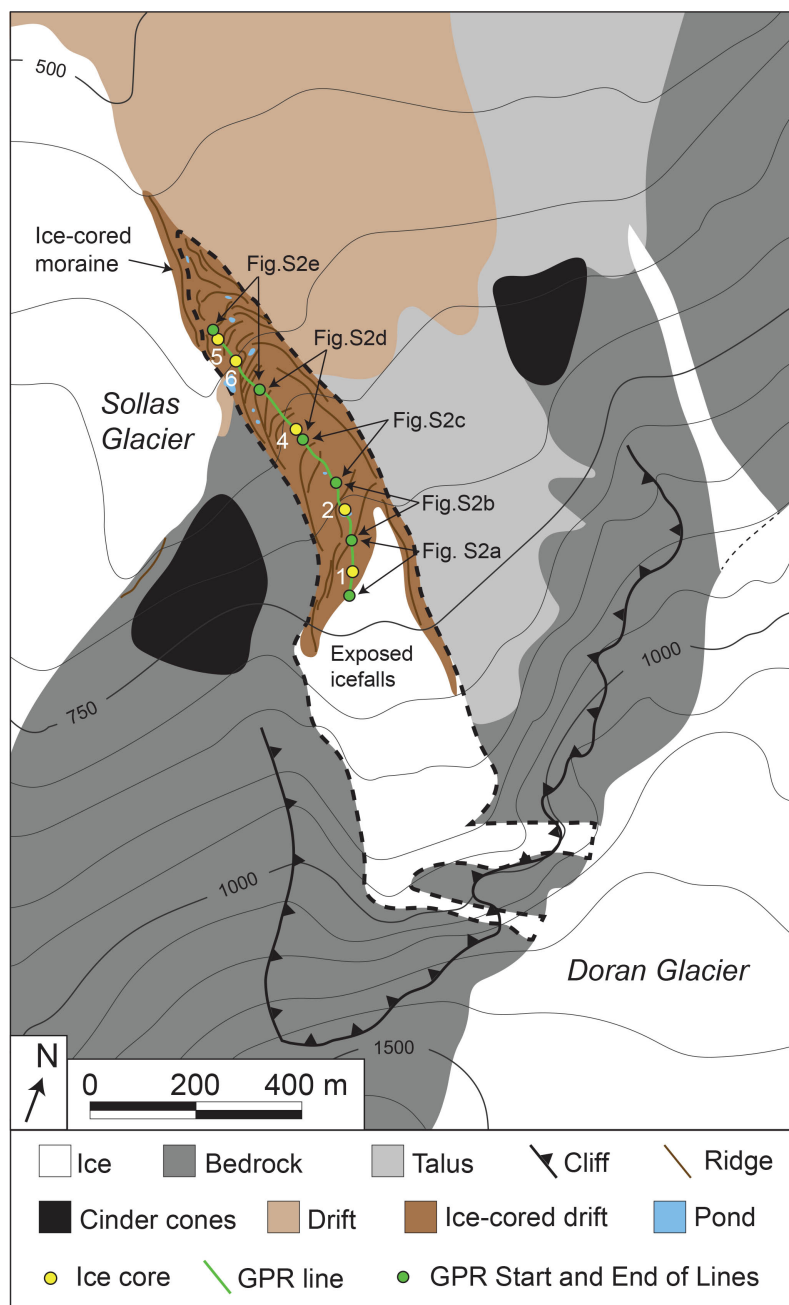
^b Depth denotes cm below surface for exposed ice and ponds and cm below the ice-sediment boundary for buried ice.

Table S2 continued. Stable isotopic data from buried ice (cores and hand samples), ponds and glaciers.

Core / Sample ID ^a	Core / sample depth (cm) ^b	$\delta^{18}\text{O}$ (‰)	δD (‰)
Buried ice hand sample			
SLI-15-08A	5	-26.8	-221.3
SLI-15-08B	5	-30.0	-243.6
SLI-15-08C	5	-30.5	-249.2
SLI-15-09A	5	-31.2	-248.1
SLI-15-09B	5	-28.1	-233.5
SLI-15-11	5	-30.1	-241.0
SLI-15-12	5	-29.8	-239.9
SLI-15-13	5	-30.0	-247.4
SLI-15-14	5	-30.4	-246.2
SLI-15-15	5	-29.6	-239.3
Pond ice			
SLI-15-02	22	-29.2	-239.4
	40	-30.5	-247.0
	52	-28.2	-233.8
	63.5	-29.6	-242.0
	74	-28.6	-235.9
	85	-30.2	-245.6
SLI-15-06	9	-29.9	-247.8
	21	-29.5	-245.6
SLI-15-07	1	-30.1	-248.8
	19	-30.2	-250.1
SLI-15-10	5	-26.9	-224.5
SLI-15-16	5	-22.7	-198.3
SLI-15-17	5	-29.8	-241.0
SLI-15-18	5	-27.7	-235.4
SLI-15-19	5	-25.3	-224.6
Glacier ice			
Sollas Glacier (KWG-4)	N/A	-30.8	-247.8
Sollas Glacier (KWG-6)	N/A	-30.7	-250.3
Doran Glacier (SOL-Marr)	N/A	-30.8	-248.8
Doran Glacier (SOL-M2)	N/A	-30.3	-238.4

^a See Tables 1 and 2 for sample locations and descriptions.

^b Depth denotes cm below surface for exposed ice and ponds and cm below the ice-sediment boundary for buried ice.



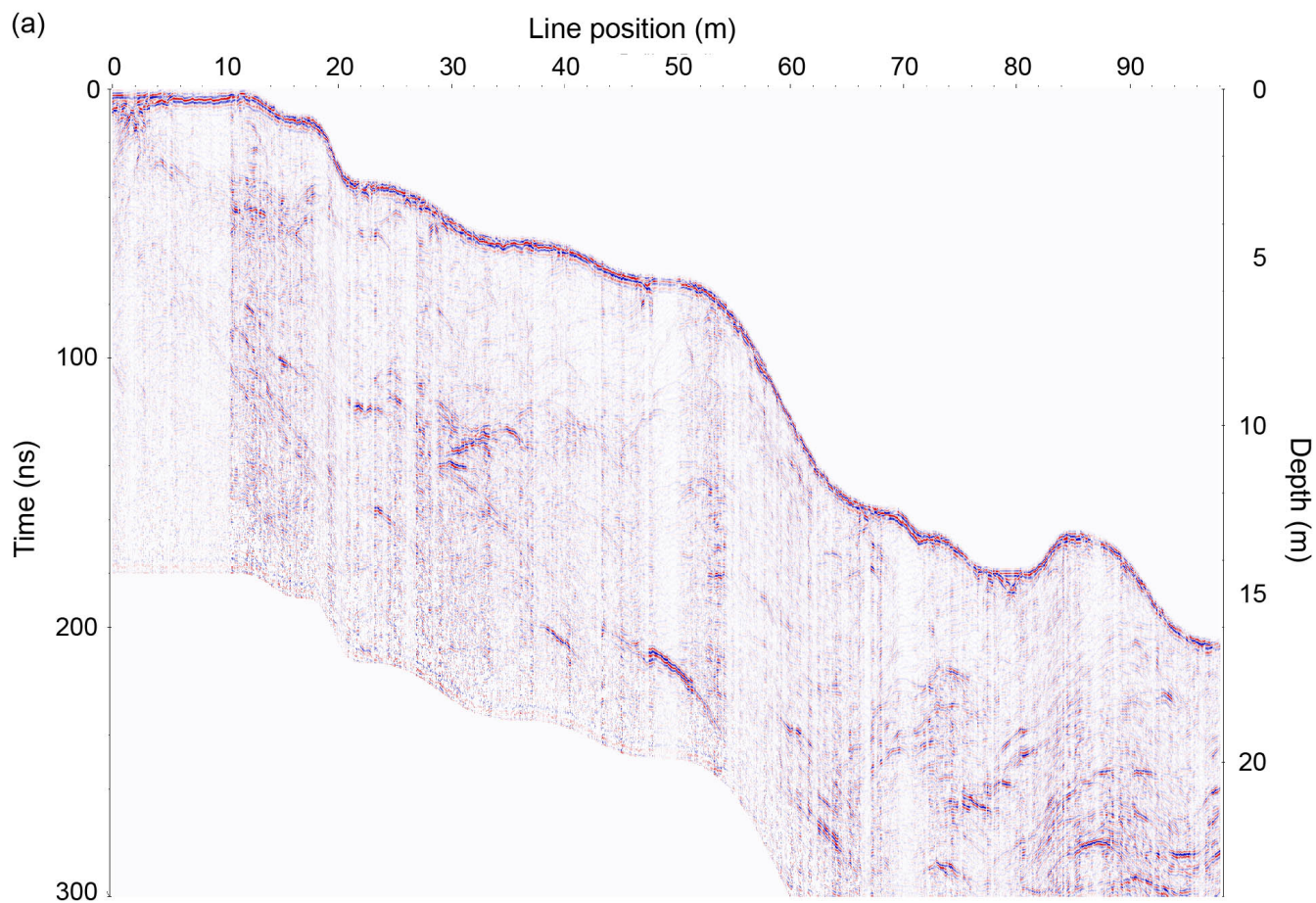


Figure S2. (a) Processed 400 MHz ground-penetrating radar data from the transect down the rock glacier. Uppermost radargram, starting at the modern boundary between exposed ice and debris-covered ice. Buried ice core SLI-15-01 was extracted near the 40-m line position.

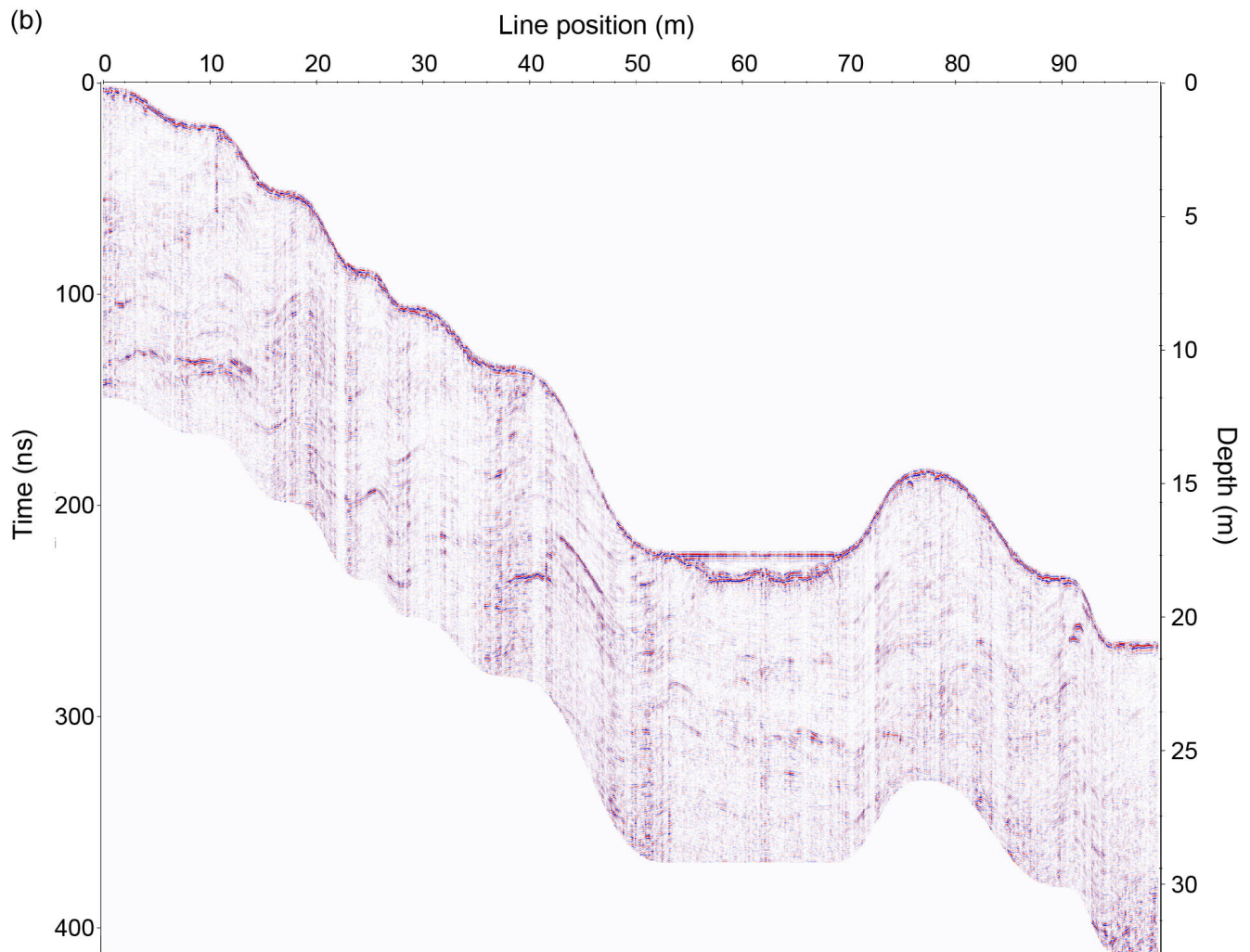


Figure S2. (b) Processed 400 MHz ground-penetrating radar data from the transect down the rock glacier, directly down flow from Fig. S1a. This radargram is duplicated from Fig. 11a. Lake ice cores SLI-15-02 and -03 were extracted from the frozen lake at 55–70 m line position.

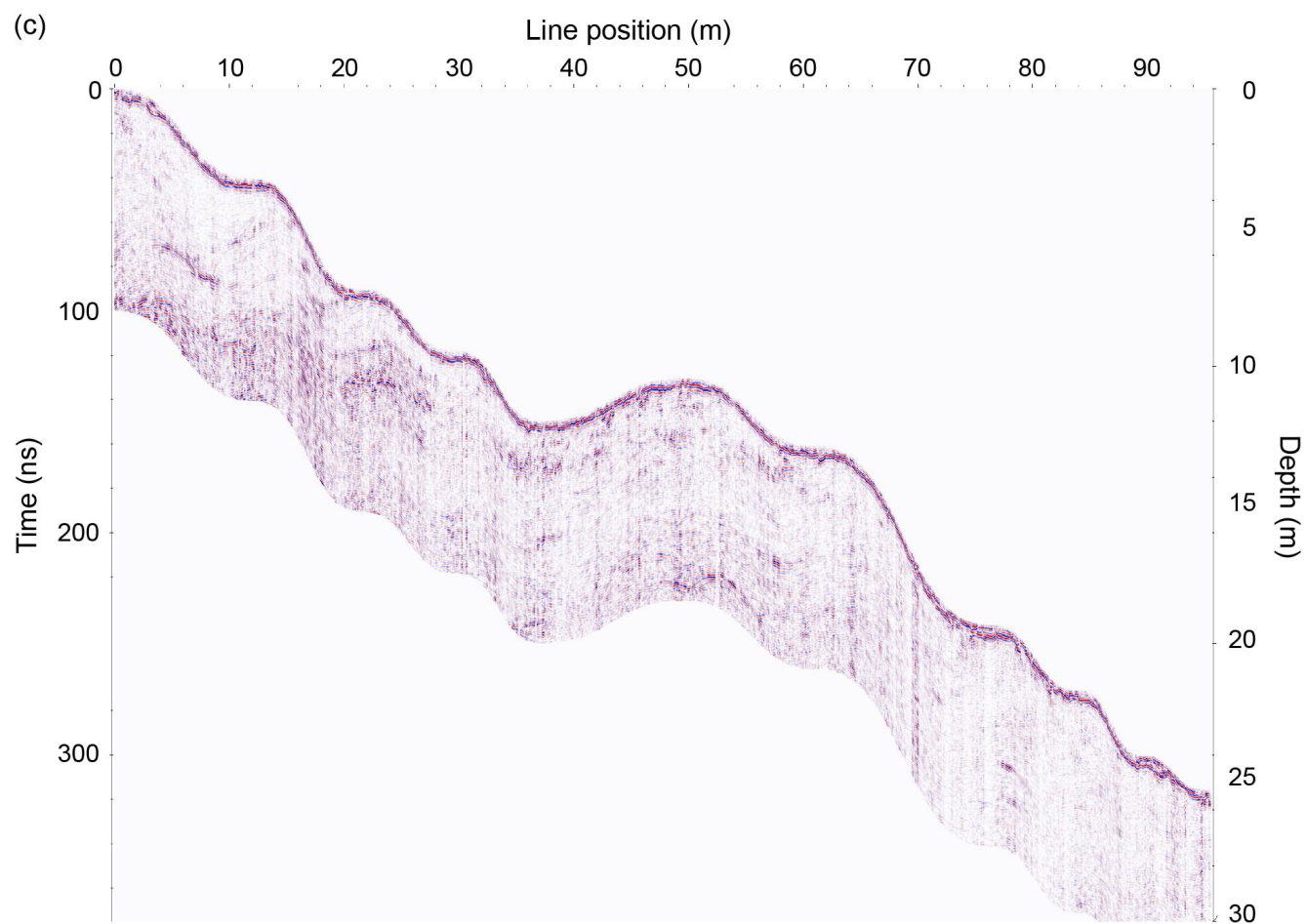


Figure S2. (c) Processed 400 MHz ground-penetrating radar data from the transect down the rock glacier, directly down flow from Fig. S1b.

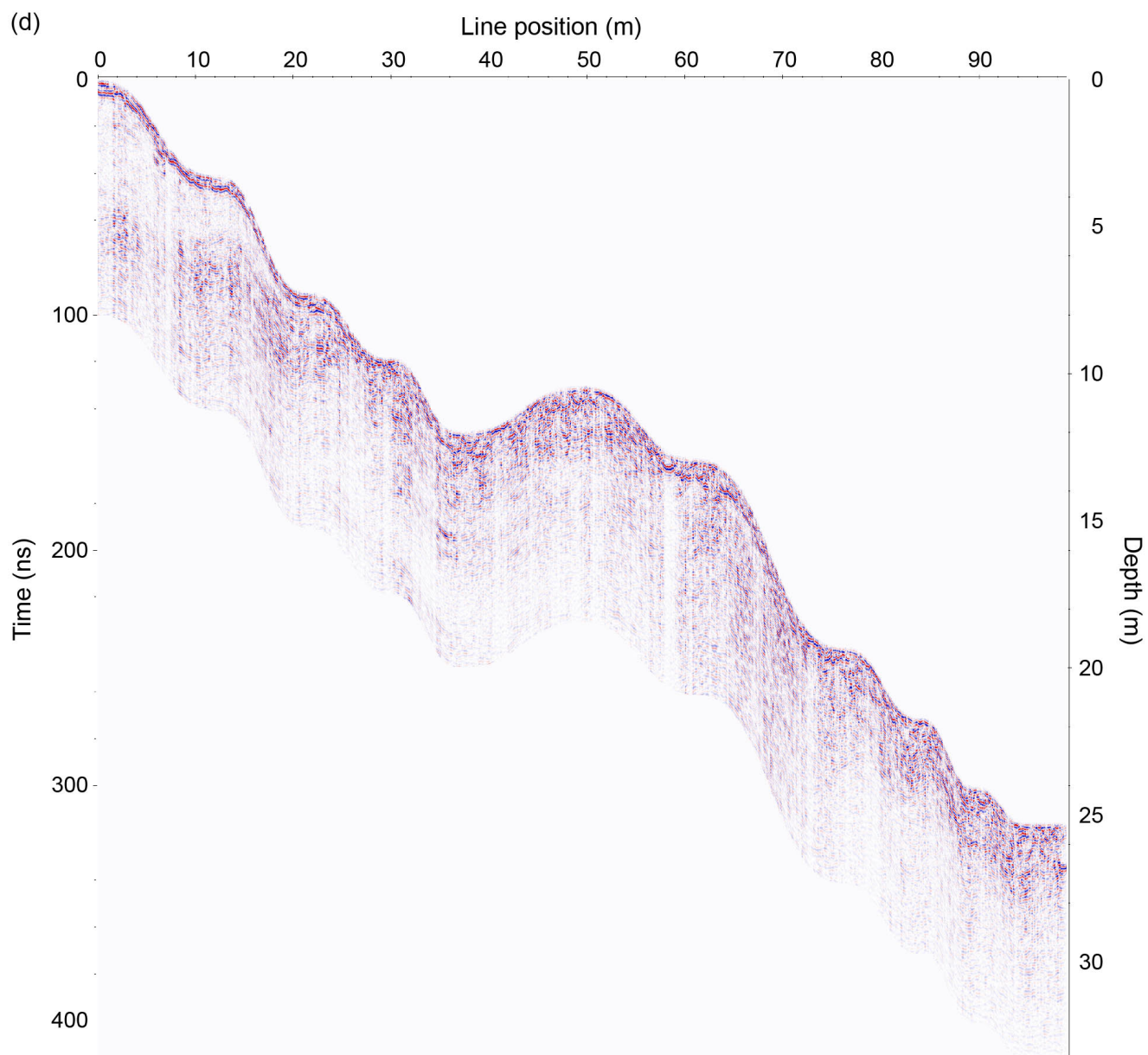


Figure S2. (d) Processed 400 MHz ground-penetrating radar data from the transect down the rock glacier, directly down flow from Fig. S1c. Buried ice core SLI-15-04 was extracted near the 10-m line position.

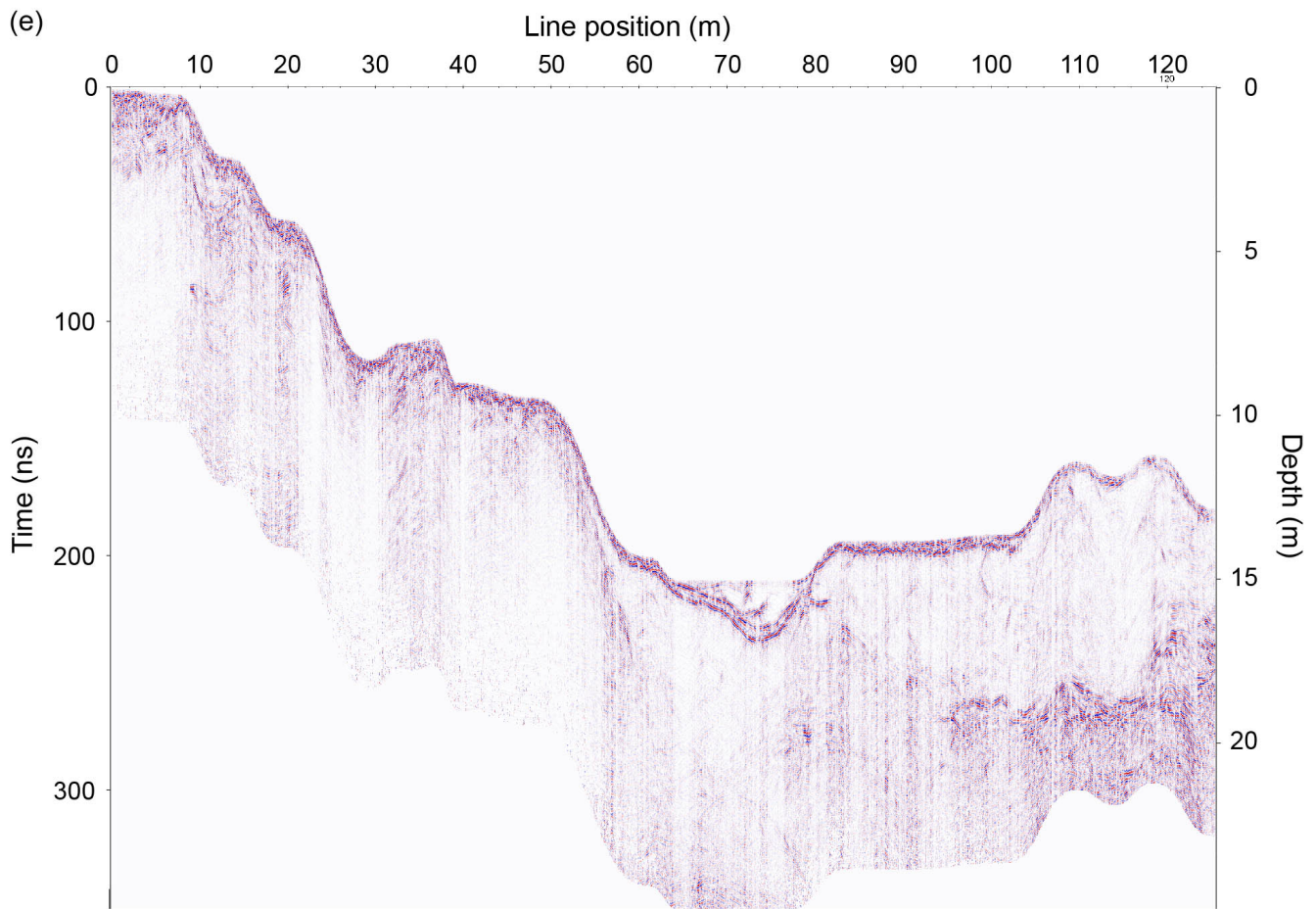


Figure S2. (e) Processed 400 MHz ground-penetrating radar data from the transect down the rock glacier, directly down flow from Fig. S1d. This radargram is duplicated from Fig. 11b. Lake ice cores SLI-15-06 and -07 were extracted from the frozen lake at 65–75 m line position. Buried ice core SLI-15-05 was extracted near the 115-m line position.